

CURRENT STATUS OF AN ORGANIC RANKINE CYCLE ENGINE DEVELOPMENT PROGRAM

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This paper presents the steps taken to achieve improved bearing life in the organic cycle (ORC) engine being developed for use on solar parabolic dishes. A summary of recent test results is also given.

The Power Conversion Subsystem (PCS) consists of an air-cooled, regenerative 25 kW_e ORC engine/generator unit mounted at the focus of a parabolic dish concentrator. The working fluid, toluene, is circulated in a hermetically-sealed, closed loop system. Toluene vapor at 750 to 800°F drives the turbine-alternator-pump assembly (TAP) at speeds up to 60,000 rpm. Liquid toluene is used as the lubricant in the hydrodynamic fluid-film bearings in the TAP.

Excessive bearing wear was experienced during solar testing of the PCS at the JPL Parabolic Dish Test Site in February and March 1982. As a result, a program was undertaken to diagnose the cause of bearing failure and remedy the problem. This effort was successful and the specific testing approaches and design changes which led to the current successful bearing system configuration are discussed in the paper.

The first series of tests in the Bearing Life Development Program was designed to characterize the performance of the radial bearing and thrust bearing designs (as individual bearings) under various combinations of controlled load, speed, lubricant flow rate and temperature.

The next series of tests utilized the actual TAP assembly. The shaft was mechanically driven at speeds up to 60,000 rpm by a special test rig. Optical proximity probes were installed to monitor shaft orbit behavior. Evidence of rotor dynamic instability (subsynchronous whirl) was observed; this led to further analyses and specific design changes in the radial bearings and lubrication feed system. However, bearing surface damage continued to appear even after the rotor instability problem was solved. This was traced to electrical pitting caused by electromagnetically-induced shaft voltage arcing across the fluid film and was corrected by design changes.

The most recent test series included operation of the entire PCS (with the TAP installed) for 100 hours of total run time in a ground test facility at Barber-Nichols Engr. Co. (B-N) which realistically simulated operation on the sun. Rotor dynamic behavior was recorded continuously during the 100 hours and the TAP was disassembled at predetermined intervals for bearing inspection. Performance of both the 5-shoe, tilting-pad radial bearings and the gimbal-mounted thrust bearings was entirely satisfactory. This test demonstrated that the objective of solving the "infant mortality" bearing problem has been accomplished. The Power Conversion Subsystem also demonstrated reliable operation over a wide range of test conditions.